Case Study: Fuel Cells Provide Combined Heat and Power at Verizon's Garden City Central Office

With more than 67 million customers nationwide, Verizon Communications is one of the largest telecommunications providers in the United States. Power interruptions can severely impact network operations and could result in losses in excess of $1 million per minute.[1] In 2005, Verizon Communications installed a 1.4-MW phosphoric acid fuel cell (PAFC) system, consisting of seven 200-kW units, at its Central Office in Garden City, New York. This fuel cell power plant, the largest in the United States at the time, is reaping environmental benefits and demonstrating the viability of fuel cells in a commercial, critical telecommunications setting.

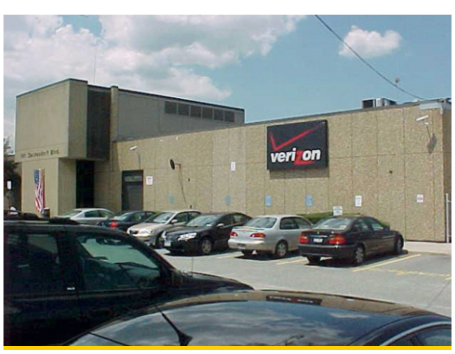

Photo credit: Verizon Communications.

A fuel cell CHP system provides primary power, heating and cooling for Verizon's Central Office.

Photo credit: Verizon Communications.

Background

Verizon's Central Office in Garden City, New York, is a 1,000-employee, 292,000-square-foot call-switching center that provides telecommunications support and service to 35,000 customers throughout Long Island, as well as to nearby international airports, JFK and LaGuardia, and to 9-1-1 emergency call services. The Central Office also houses a critical network-monitoring center servicing the Northeast Corridor and cannot tolerate power outages. In addition, the devices used for call-switching generate significant heat during operation and must be kept cool to maintain reliable phone connectivity. This requirement, the need for reliable power, high local electricity rates ($0.12 to $0.14/kWh), and Verizon's continuing commitment to the environment were key drivers leading the Central Office to consider alternatives to grid electricity.

Project Planning and Evaluation

Following several costly power outages and interruptions between 1999 and 2001, Verizon created an energy team to investigate alternative solutions to bolster electric reliability, optimize the company's energy use, and reduce costs in an environmentally responsible manner. The energy team, after recommending the use of a large fuel cell system at the Garden City Central Office, selected UTC Power's PC25C phosphoric acid fuel cells (PAFCs) based on the proven performance and longevity of this company's fuel cell systems.

System Configuration

During normal operation, all seven fuel cells run continuously, supplementing electricity from the grid. Year-round electrical loads vary between 2.2 and 3.3 MW, averaging about 2.5 MW. During the heating season (November through March), cooling water conveys waste heat from the fuel cells to an unfired furnace for space heating, providing about 75% of space-heating needs. The remaining space-heating and other thermal needs are met by the boilers. Early in the project Verizon decided not to utilize the

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fuel cell's low temperature waste heat since the possible uses for that heat were widely dispersed in the building and the costs to integrate that heat would be prohibitive.

During the cooling season (April through October), the high-grade waste heat from the fuel cells is used in two 70-ton lithium-bromide absorption chillers, which require approximately 17,000 Btus (17.9 MJ) per hour per ton of cooling capacity. The absorption chillers' internal pumps consume approximately 0.07 kW (supplied by the grid) per ton of cooling. The highly efficient absorption chillers require far less electricity per ton of cooling than the former electric chillers, which required 0.73 kW from the grid per ton of cooling. It is estimated that the absorption chillers powered by fuel cell thermal energy reduced the cooling load by approximately 1.7 million ton-hours, saving 1.1 MWh.

Increased demand during the cooling months can stress the grid, resulting in reduced power quality, more frequent brownouts, and possibly blackouts. To meet this excess demand, the local utility may add generation capacity or facilities may choose to utilize distributed generation to ensure reliability. During this time, the Central Office's increased demand exceeds the output of the seven fuel cells. To compensate, five of the fuel cells and one gas-fired generator (whose electric output exceeds the output of two fuel cells) are used to meet the buildings' peak electricity demand, preventing the grid from becoming overly strained. When the five fuel cells are used in combination with the generator for distributed generation, peak shaving is accomplished, and the utility no longer needs to add generation capacity to meet peak demand. Currently, gas turbine peaking units are the technology of choice for peak shaving. However, compared to fuel cells, these are less efficient and produce significant air pollutants.

The Central Office's monitoring system is designed to ensure that potential problems are identified quickly. This system monitors heat recovery, the state of the fuel cells, and emergency backup systems, and uses intelligent decision making to optimize the mix of onsite generated power and electric grid power.

Installation

Construction permits were required for site preparation and fuel cell installation. Although no air permit was required for the fuel cells, a facility air permit was issued by the New York State Department of Environmental Conservation for other onsite emissions sources, including the generators.

Infrastructure upgrades needed to facilitate deployment of the fuel cell system included installation of power, instrumentation, controls; and piping and conduit to supply natural gas, de-ionized water, nitrogen, and fuel cell cooling water. Several aging electrical transformers were replaced and the existing generators were modified for natural gas in lieu of heating oil operation. In addition, two absorption chillers and a furnace were added to utilize the fuel cell thermal energy for cooling and heating. All these costs, including infrastructure upgrades, were included in the total system cost.

While the phosphoric acid fuel cell produces enough water to satisfy its own needs, some additional site water is required on hot summer days when temperatures exceed 85°F. As a solution, Verizon constructed a small building housing deionization and reverse-osmosis equipment for use during those days. A separate enclosure was built for storing nitrogen gas, which is required to flush the fuel cells at startup and shutdown. These special facilities added to the cost of the project.

The response time of the fuel cell system to provide electric power as quickly as the telecom switches require in the event of a sudden grid outage presented an initial challenge. The site designers decided to use the onsite uninterruptible power supply (UPS) system to supply the telecom switch load during the switchover to full fuel cell operation.

Maintenance

The fuel cells require less than three days of maintenance per year, typically performed during the summer when two of the fuel cells are shut down. Routine maintenance is also performed on the absorption chiller system and, to date, no problems have been encountered with this auxiliary system.

Cost

The total cost to upgrade the Central Office and install the fuel cell system and additional equipment was $15.7 million. Government support included $2.5 million from the U.S. Department of Energy (Office of Energy Efficiency and Renewable Energy), $1.0 million from the U.S. Department of Defense Climate Change Program, and $390,000 from the New York State Energy Research and Development Authority. At the time Verizon purchased the fuel cells and associated equipment for this project the Federal Investment Tax Credit (ITC) was not yet in place. Had the ITC been in place, Verizon would have paid $3,000/kW or 30% less. Annual operating savings enabled by the fuel cells vary from month to month, depending on the cost of natural gas compared to the avoided cost of purchasing electricity from the grid.

Verizon Central Office combined heat and power fuel cell system.

Photo credit: Verizon Communications.

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Project Summary (through end of 2007)

Location	Verizon Communications Central Office, Garden City, New York
Objective	Reliable prime power and heating, and reliable cooling for critical telecommunication needs
Incumbent Technology	Grid electricity/emergency generators, and oil-fired boilers
System and Manufacturer	Seven 200-kW PAFC systems manufactured by UTC Power in parallel with the grid plus three generators for backup/peak shaving, and lithium bromide chillers powered by fuel cell thermal enesrgy
Fuel Cell Startup Date	Mid 2005
Fuel Supply	Natural gas from utility pipeline distribution system
Availability	97%
Efficiency (Lower Heating Value)	Electrical Efficiency—37-39% Thermal Efficiency—22%[2] Combined Heat and Power Efficiency—59-61%
Emissions Avoided by Displacing Grid Electricity and Using Fuel Cell Thermal Energy to Displace Inefficient Chillers and a Fraction of Oil-Fired Boilers, Metric Tons	NO_X: 19 CO_2: 5,160 SO_X: 48
Fuel Cell Cost Before Grants (DOD, DOE, NYSERDA)	$875,000 per fuel cell
Total System Cost After Grants	$11.8 million (includes seven fuel cells, two lithium bromide chillers, furnace, transformers, engineering, facility/site modifications, and generator conversions from oil to natural gas)

Project Results

The seven fuel cells at Verizon's Central Office have demonstrated a combined availability of 96.57%, providing highly reliable premium power whose quality exceeds that of grid electricity. The fuel cell power plant's electrical efficiency is estimated at 37-39%, with a thermal efficiency of 22%,[2] bringing the combined heat and power efficiency to 59-61%. In addition, the operation of the fuel cells resulted in a significant reduction in CO_2, NO_X and SO_X emissions.

In 2008, the U.S. Environmental Protection Agency and U.S. Department of Energy awarded their prestigious Energy Star Combined Heat and Power Award to Verizon for this system.

For more information about hydrogen and fuel cells, visit: www.hydrogenandfuelcells.energy.gov.

During the cooling season, the high-grade waste heat from the fuel cells is used by two lithium bromide absorption chillers, contributing about 33% of the energy required for cooling.

Photo credit: Verizon Communications.

Emissions Reductions from Fuel Cell Power Plant Operation between July 2005 and December 2007 [3,4]

Emissions Sources		NO_x	CO_2	SO_x
Electricity from Fuel Cells	Electric Grid Emissions, lbs/MWh (kg/MWh)	1.48 (0.67)	1,440 (654)	4 (1.82)
	Fuel Cell Emissions, lbs/MWh (kg/MWh)	0.035 (0.016)	1,220 (554)	Below detection limit
	Net Savings, lbs (kg)	**36,600 (16,640)**	**5,680,000 (2,582,000)**	**101,000 (45,910)**
Absorption Chillers with Fuel Cell Waste Heat (grid electricity only used for pumps)	Emissions Associated with Grid Electricity used by Centrifugal Chillers, lbs	1,840 (836)	1,800,000 (818,200)	5,000 (2,270)
	Emissions Associated with Grid Electricity used by the Absorption Chiller Pumps, lbs	190 (86)	183,000 (83,200)	510 (232)
	Net Savings, lbs (kg)	**1,650 (750)**	**1,617,000 (735,000)**	**4,490 (2,040)**
Fuel Cell Waste Heat used to Generate Steam	Emissions from an Oil-Fired Boiler that is 85% Efficient	3,500 (1,590)	3,800,000 (1,727,000)	44 (20)
	Emissions Associated with Fuel Cell Waste Heat (None – All Allocated to Electricity from Fuel Cells)	0	0	0
	Net Savings, lbs (kg)	**3,500 (1,590)**	**3,800,000 (1,727,000)**	**44 (20)**
Total Emissions Avoided (Sum of Net Savings), lbs (Metric Tons)		**41,750 (19)**	**11,097,000 (5,040)**	**105,500 (48)**

Note: Fuel cell output and electrical efficiency were measured by KeySpan Energy Services (now National Grid).

References and Notes

1. Ditoro, T.J. "Banking on Fuel Cells: Increased Efficiency and Availability with Fuel Cells. "HDR, Inc, 2000.

2. Verizon decided not to integrate the lower temperature heat from the fuel cell with the building's sanitary facilities because of the additional cost. Implementation of this additional waste heat stream would have increased the overall thermal efficiency by another 10%.

3. U.S. EPA, eGrid 2007 Version 1.1, Year 2005 Summary Tables, NPCC Long Island (fossil fuel output). http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html. (accessed February 13, 2009).

4. Personal communication with Joseph Staniunas, UTC Power, 2009.